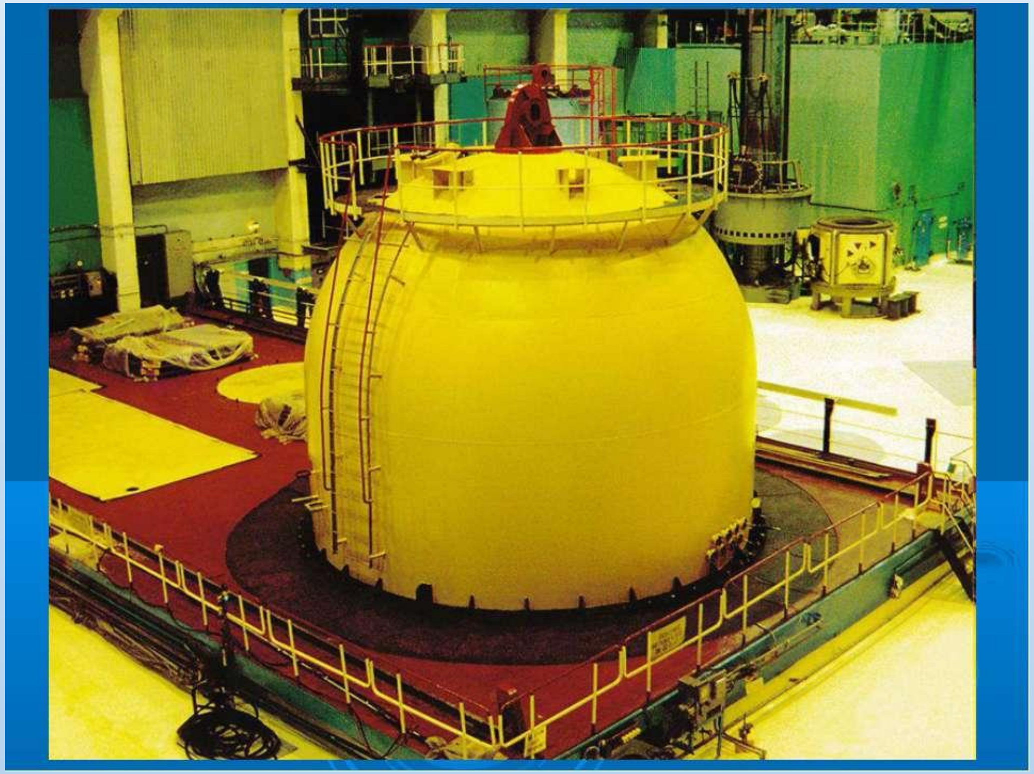
NUCLEAR REACTOR MONITORING BY ANTINENTRINO DETECTORS

Prepared by
professor Boyarkin O.M.
and student Pinchuk A.V.

NUCLEAR REACTOR MONITORING

Nuclear reactor monitoring in the “on-line” regime is a field of intensive activity of applied neutrino physics. The nuclear reactor represents exceptionally clean and powerful source of electron antineutrinos.



REACTOR NEUTRINO DETECTION

- Inverse Beta Decay(IBD)

$$p + anti - v_e \rightarrow e^+ + n$$

$$cross\ section\ \sigma = 5 \cdot 10^{-43} cm^2\ (E = 2MeV);$$

- Neutrino-Electron Scattering

$$e^- + anti - v_e \rightarrow e^- + anti - v_e$$

$$cross\ section\ \sigma = 5 \cdot 10^{-45} cm^2\ (E = 0.8MeV)$$

- Inverse Beta Decay(IBD)

$$A + anti - v_e \rightarrow A + anti - v_e$$

$$cross\ section\ \sigma = 5 \cdot 10^{-41} cm^2\ (E > 2MeV)$$

FEATURES OF REACTIONS

- ✓ The antineutrino flux produced by the reactor is proportional to the number of fissions taking place in an active zone
- ✓ Theoretical calculations and experimental data show that the spectra of $\bar{\nu}_e$ emitted by different components of nuclear fuel differ from each other

THE EXPERIMENT OF RUSSIAN PHYSICISTS

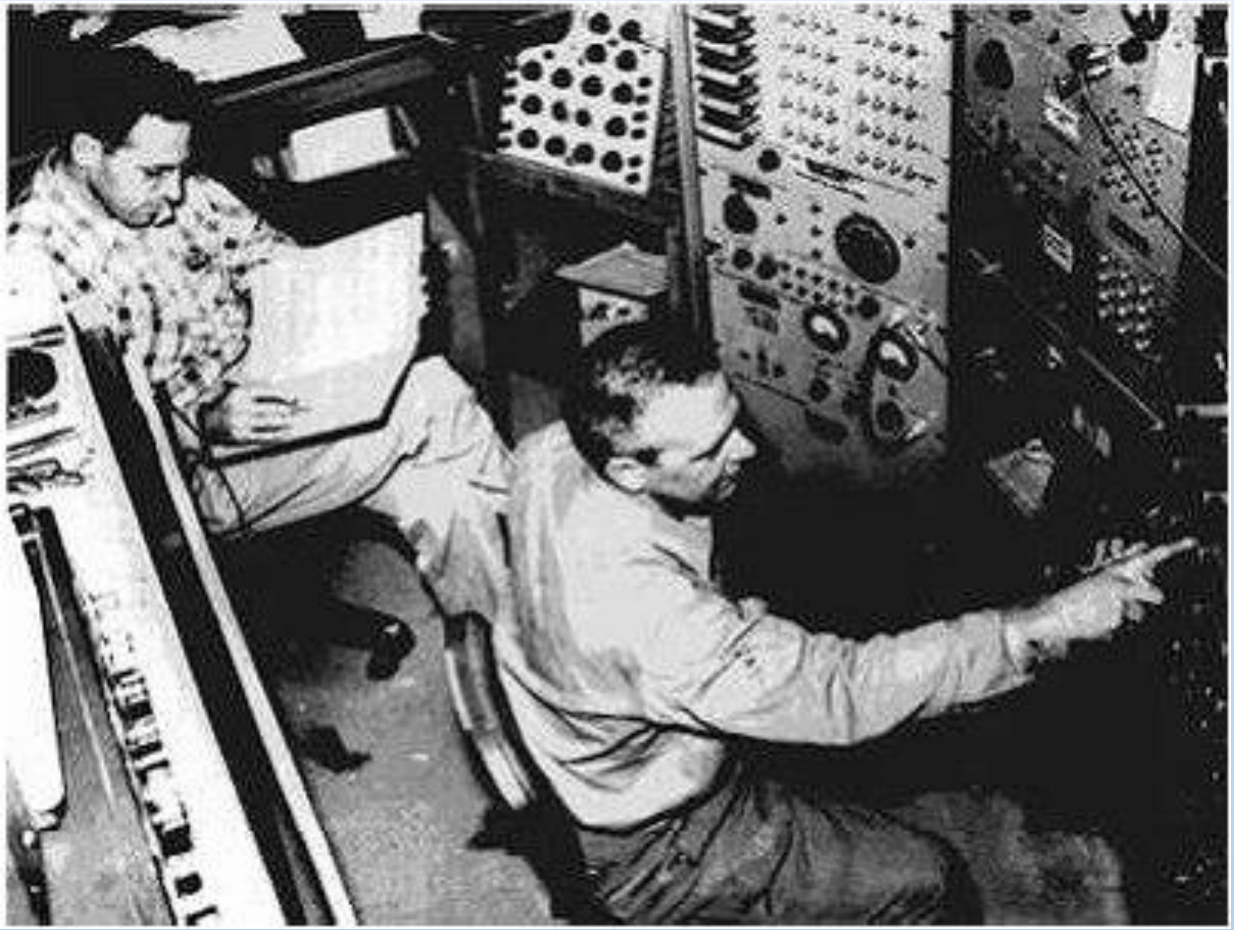
The first to exploit antineutrino detection as a tool for reactor monitoring were Russian physicists. Multiple experiments were conducted, beginning in 1982 , at the Rovno Atomic Energy Station in Kuznetsovsk, Ukraine,. The antineutrino source was a Russian VVER-440.

THE EXPERIMENT OF RUSSIAN PHYSICISTS

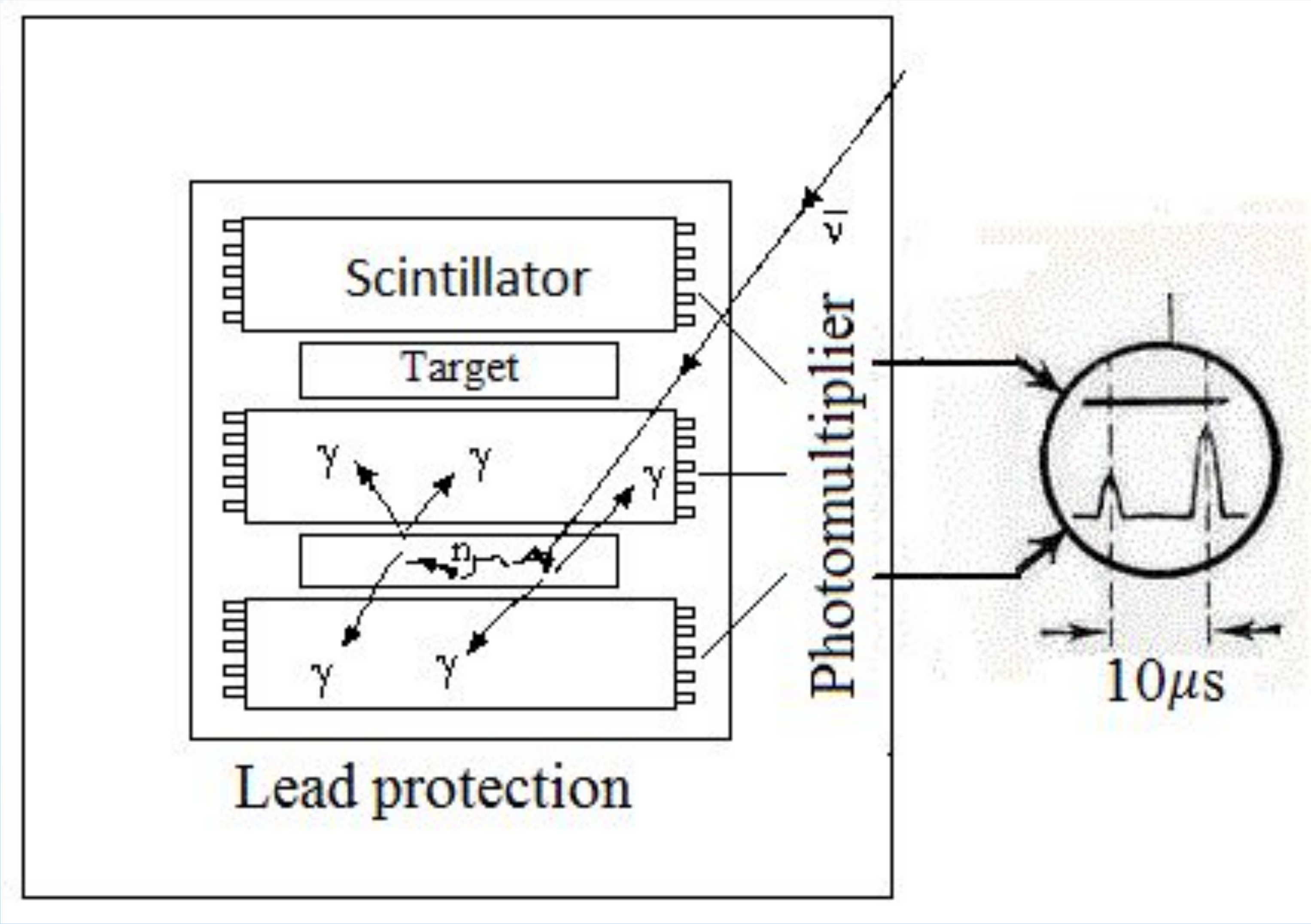
For the antineutrino flux to be detected, the inverse beta-decay was used.

In the Rovno experiments, two neutrino detectors were in operation:

- Scintillation spectrometer (ScS);
- Water integral neutrino detector (WIND).



SCINTILLATION SPECTROMETER (ScS)



The scheme of installation

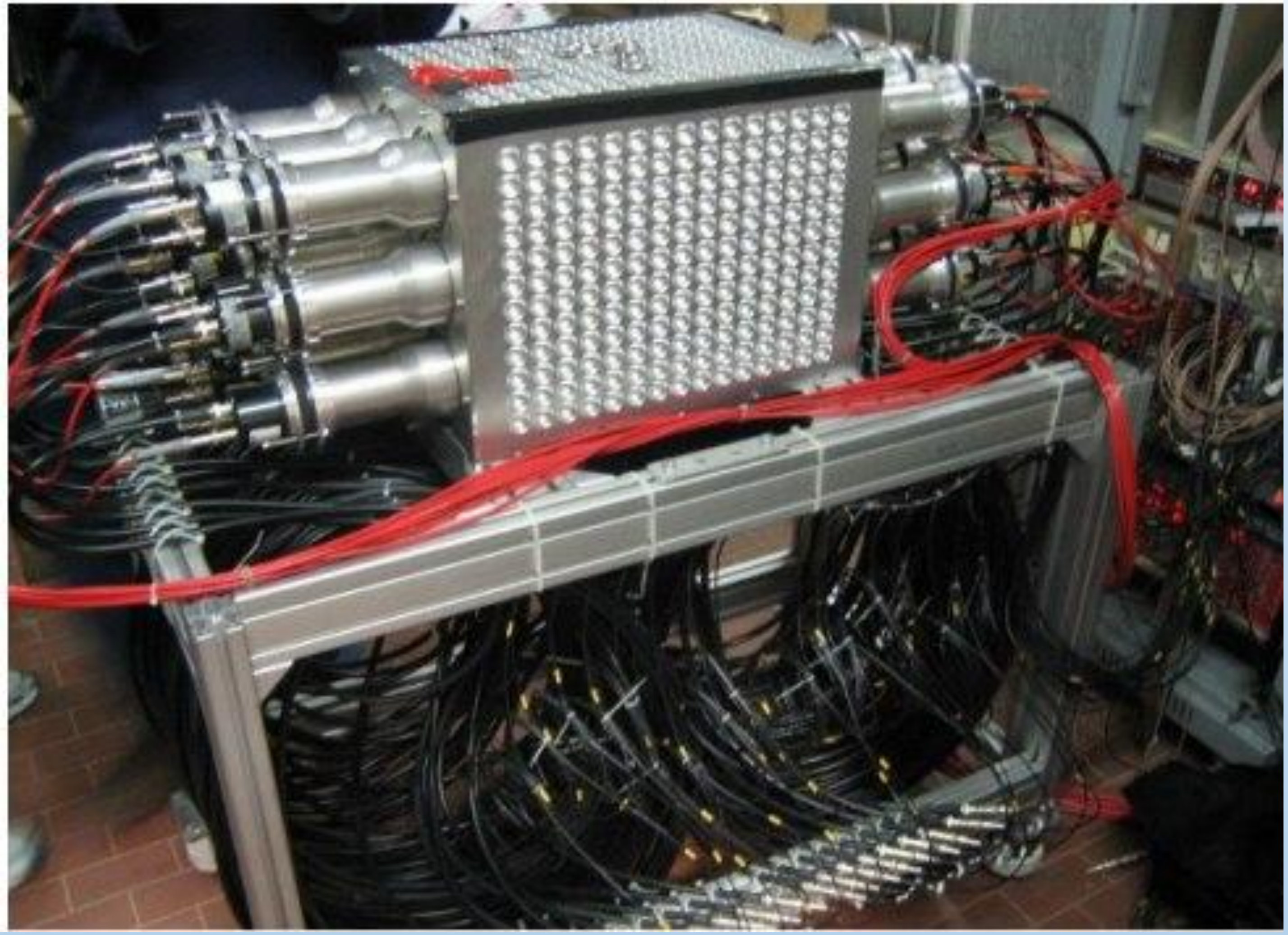
F.Raines

C.Cowan

THE PARAMETERS OF MODERN DETECTORS

- volume of about one cubic meter;
- based on the inverse beta-decay;
- high statistic accuracy;
- statistics can detect a net antineutrino rate of about

DANSS



- relatively simple design;
- small number of channels;
- readily available raw materials;

CONCLUSION

Today, Thirty-three years after the Russian demonstrations at Rovno and six years after the first IAEA experts meeting on this topic, there are now many efforts to explore the potential of the antineutrino detectors all around the world.

THANK YOU FOR YOUR ATTENTION!